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Revealing fatigue damage evolution in unidirectional composites for wind turbine blades using x-ray computed tomography

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Understanding fatigue damage evolution in the load carrying laminates of wind turbine blade play an important role designing longer and lighter turbine blades. Turbine blades which will make it possible to increase the size of wind turbines or to upgrade existing turbines for lower wind classes'. Thereby, it will be possible to lower the cost of energy for wind energy based electricity. In the presented work, a lab-source x-ray computed tomography equipment (Zeiss Xradia 520 Versa) has been used in connection with ex-situ fatigue testing of uni-directional composites in order to identify fibre failure during the fatigue loading. The load carrying laminates in wind turbine blades is typically based on a number of non-crimp fabrics in where the load carrying fibres are oriented in the axial direction of the blades. In order to ease the handling of the fabric during the dry fabric layup and to ensure a good alignment of the final laminates, approximately 10% of the fibres are oriented in secondary directions as so-called backing bundles and stitched to the uni-directionally oriented bundles. Due to the coarse structure of the non-crimp fabric, test samples with a larger cross-section (compared to other comparable x-ray studies) have been used in order to ensure a representative test volume during the ex-situ fatigue testing. Using the ability of the x-ray computed tomography to zoom into regions of interest, non-destructive, the fatigue damage evolution in a repeating ex-situ fatigue loaded test sample has be explored. Thereby, the fatigue failure mechanism has been uncovered showing fibre breakage regions growing from cross-over regions of the backing bundles. Based on those observations, more realistic micromechanical based fatigue damage models as well as suggestions on bundle arrangement improving the fatigue resistance of non-crimp fabric used in the wind turbine industry can be made.